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DISEASES OF TOBACCO IN CANADA

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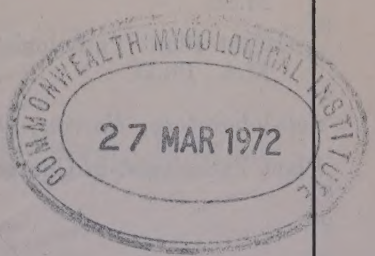

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TABLE OF CONTENTS

	Page
Introduction	5
Certain Diseases May be Carried from the Seed-bed to the Field	5
Seed Selection and Treatment	5
Sanitation	5
Sterilization of the Soil	6
Fertilization	6
Ventilation and Watering of the Seed-bed	7
Diseases of the Seed-Bed	7
Damping-off	7
Blackleg	8
Chlorosis	8
Mushrooms, etc.	9
Yellow Patch	9
Blue Mould	9
Field Diseases	11
Mosaic	11
Ring Spot	13
Streak	14
Black Root-rot	15
Brown Root-rot	18
Angular Leaf Spot	20
Wildfire	21
Non-Parasitic Leaf Spot	22
Frenching	24
Hollow-Stalk	25
Root-Knot	25
Albinism	26
Lightning Injury	26
Hail Injury	26
Symptoms on Tobacco Associated with a Deficient Supply of Certain Chemical Elements	28
Potash Deficiency	28
Nitrogen Deficiency	29
Phosphorus Deficiency	29
Magnesium Deficiency (Sand Drown)	29

85289—1½

DISEASES OF TOBACCO IN CANADA

G. H. Berkeley and L. W. Koch

INTRODUCTION

The present-day large scale production of tobacco in Canada had its beginning when flue-cured tobacco was introduced in Ontario about 1906. Since then the acreage has increased more or less steadily until in 1938 some 95,000,000 lb., at an estimated value of $20,000,000, were produced on 83,000 acres. During these years of increasing acreages various diseases began to make their appearance, until to-day mosaic, black root-rot, brown root-rot, and various leaf spots have become widely distributed and are of considerable economic importance. In 1932 the Laboratory of Plant Pathology at St. Catharines, in co-operation with the Tobacco Division, and the staffs of the Dominion Experimental Stations at Harrow and Delhi, Ontario, and L'Assomption and Farnham, Quebec, initiated a special investigation of the diseases of tobacco.

There are five main tobacco-growing districts in Canada, of which the acreages produced in 1938 were as follows. The New Belt in Ontario, comprising Norfolk, Elgin, Oxford, Middlesex, and Brant counties, is the greatest producing area, with approximately 56,700 acres of flue-cured tobacco. In the Old Belt consisting of Essex and Kent counties, 4,300 acres of flue-cured tobacco, 9,230 acres of burley, and 3,000 acres of dark tobacco were grown. In Quebec, production of tobacco amounted to 9,100 acres of cigar, pipe, and dark varieties (about 7,100 acres in the northern district and 2,000 in the southern district) and 1,850 acres of flue-cured varieties in the northern district. In British Columbia, about 380 acres of flue-cured tobacco were grown in Sumas district.

Certain Diseases May be Carried from the Seed-bed to the Field

Since many of the serious diseases such as mosaic, black root-rot, blackleg, wildfire, blue mould, and angular leaf spot, encountered in the field may originate in the seed-bed, the main aim of seed-bed management should be prevention. To this end, selection and treatment of seed, strict sanitary measures, sterilization of soil, and careful attention to fertilizing, watering, and ventilating are essential.

Seed Selection and Treatment

Seed should be selected from healthy plants only. Although disinfection of seed is not generally practised in Ontario or Quebec, it is recommended in the case of seed of unknown or doubtful origin. This is particularly true if the seed has been obtained from districts where seed-borne bacterial leaf spots and blue mould are serious diseases. The safest material to use is silver nitrate 1:1,000, i.e., 1 part of silver nitrate (14 grs.) to 1,000 parts of water (1 qt.). Place the seed in a cloth bag and immerse in silver nitrate solution for 15 minutes, then spread out to dry. The seed is ready for use when dry.

Sanitation

1. The seed-bed should not be located near the curing barn or warehouse.

2. Boards and cloth covers that are to be used a second time should be disinfected. This may be accomplished in the case of the former by exposure to steam for 30 minutes, or by spraying with 3 per cent formaldehyde and

then covering with wet bags or papers for about 48 hours. Cloths should be boiled in water for 10 minutes. Tools used in working the seed-bed should not be stored in any building where tobacco is stored or handled.

3. Tobacco trash, manure, and manure water should not be used in the seed-bed, but if for some reason they are used, they should be added to the soil before it is sterilized.

4. Special care should be taken to see that the refuse from the previous year's crop does not come in contact in any way with the seed-bed.

5. Tobacco stalks should not be used for insulating or drainage purposes under the seed-bed, because if so used, they may infect the seed-bed with mosaic, or certain fungous and bacterial diseases.

6. Neither tobacco smoking nor chewing should be permitted while working in the seed-bed.

7. Before work is begun in the seed-bed, the hands should be thoroughly washed with soap, under running water preferably.

Sterilization of the Soil

From the standpoint of disease control, the most important single step is the sterilization or disinfection of the soil in the seed-bed. This may be accomplished by means of steam or formaldehyde. If sterilization is effected by steam, not only are the disease-producing organisms killed, but in addition, weed seeds are destroyed, and plant nutrients in the soil are rendered more readily available to the seedlings. If disinfection is effected by formaldehyde, the disease-producing organisms are killed, but the destruction of weed seeds is not always complete, and there is no resulting increase of available nutrients in the soil. Therefore, sterilization by steam is preferable. If steam is used, it is especially important to spade the soil previous to steaming, and to have the soil moist—not too wet nor yet too dry—since satisfactory penetration by the steam is not possible if the soil is compact, dry, wet, or frozen. When the soil is in a satisfactory condition, that is, loose, and just moist enough to hold its shape when squeezed tightly in the hand, excellent results may be obtained by steaming for 30 minutes, provided pressure at the boiler is between 90 and 100 lb. It is preferable that seed should not be sown until at least 10 days after sterilization, since freshly sterilized soil often has a temporarily detrimental effect on growth of seedlings. If formaldehyde is used, the soil should be loose and comparatively dry, so that it may be able to soak up the formaldehyde solution. Formaldehyde solution made up of 1 gallon of formalin to 50 gallons water should be applied at the rate of $\frac{1}{2}$ to 1 gallon per square foot of soil. Then papers or gunny sacks soaked in formalin should be placed over the soil for at least 48 hours in order to retain the active formaldehyde fumes. After 48 hours the bags should be removed and the soil should be turned over or aerated at intervals until the odour of formaldehyde is extremely faint or lacking. This may require as long as 10 days.

Sterilization either by steam or formaldehyde may be done late in the fall or early in the spring. Fall sterilization has some advantages, though obviously there is the chance of re-infection by weed seed or disease-producing organisms before spring. Sterilization in the fall is more convenient from the standpoint of time and labour, and often permits earlier seeding, due to the fact that in the spring unfavourable weather conditions sometimes necessitate delay in sterilization.

Fertilization

There is some evidence that heavy fertilization of the seed-bed, especially with manure, favours "yellow patch" and other seed-bed troubles. Hence

over-fertilization should be avoided. If a suitable muck is used, the only treatment necessary is an application of 100 to 125 pounds of an ordinary tobacco fertilizer per 900 square feet of bed, well worked into the muck before seeding.

Ventilation and Watering of the Seed-bed

In the production of tobacco seedlings, temperature and moisture conditions are most important. Too high or too low a temperature and too humid an atmosphere may not only adversely affect the germination of the seed but, at the same time, may favour certain diseases. Therefore, it is essential to maintain suitable temperatures for germination and to avoid an atmosphere that is too humid or a soil that remains wet for too long a period. To this end the temperature should be maintained between 80° and 90° F., since tobacco seed germinates best at these temperatures, and humidity should be controlled by adequate ventilation and care in watering. During the short but critical period of germination, seed-beds should be kept moist with frequent light sprinklings, rather than with fewer but heavier applications. Watering should be done around mid-day in order that the humidity may be greatly reduced before night. These practices will reduce to a minimum damage from damping-off and other seed-bed diseases.

DISEASES OF THE SEED-BED

Damping-off

Damping-off as a rule appears in patches. Affected plants which are commonly attacked near the ground line wilt and ultimately die. In a moist atmosphere a wet rot may develop, sometimes accompanied by a white mould on the rotted plants. In a drier atmosphere affected seedlings may dry up and show no signs of mould. In some cases young seedlings are killed before they emerge.

Cause

Damping-off may be caused by several fungi, commonly present in soils, but which may be killed by steam sterilization.

Conditions Favouring the Disease

A humid atmosphere, wet soil and thick stands of seedlings all favour damping-off. Where any of these conditions prevail, the disease may destroy entire seed-beds in a relatively short time.

Control

1. Use sterilized soil in the seed-bed. 2. Ventilate beds as much as possible. 3. Avoid heavy and too-frequent watering. 4. Aim to have the surface of the bed as dry as possible by evening. 5. Avoid too thick a stand of seedlings. Seeding at the rate of 1 ounce of seed to 1,200 to 1,600 square feet is recommended, depending, of course, upon the germination test of the seed. 6. If damping-off appears in the seed-bed, dig out the diseased patches and disinfect with formaldehyde or corrosive sublimate* the area from which plants were taken. Also reduce watering to a minimum and increase ventilation, keeping in mind, however, that tobacco seedlings do not stand chilling.

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* Formaldehyde is prepared as outlined under section headed "Sterilization of the soil". Corrosive sublimate is used at the rate of 1 oz. to 10 gals. of water. This is a deadly poison and should be handled with great care. As it corrodes metal, it should be prepared in a glass, earthenware, or wooden vessel.

Blackleg

This is a bacterial disease that may, at times, cause considerable loss in the seed-bed, particularly if the stand of seedlings is too thick, and humid conditions prevail.

Symptoms

The conspicuous symptom of blackleg, as its name implies, is a black rot either along one side or completely girdling the stem from the ground line upwards. As a rule the disease is localized in distribution, and seldom makes its appearance until the seedlings are almost large enough to be transplanted.

FIG. 1.—Blackleg on tobacco seedlings. Note blackened stem near ground line.

Control

As far as is known, the practices recommended for control of damping-off should give satisfactory control of blackleg.

Chlorosis

For the past few years in Essex county, Ontario, an abnormal condition of tobacco has been observed which is characterised by a chlorosis or yellowing of the tissues between the veins of the young leaves. This condition only appears when the plants are at the 4- to 6-leaf stage and when severe, it can readily be identified at some distance. Usually the yellowing is most pronounced on, and sometimes limited to, the two centre leaves. In other cases only the edges of the outer leaves become yellow. It is characteristic for this condition to appear quite suddenly throughout part or all of the seed-bed, and to disappear quite as suddenly. Roots of seedlings affected in this way appear to be normal.

As yet there is no satisfactory explanation or control for this condition, though conditions which encourage growth, and cool nights appear to favour its development.

Mushrooms, etc

Different fungi which thrive on decaying organic matter may cause some damage in seed-beds. In Kent county, Ontario, and in Quebec, where steaming of seed-beds is not generally practised, considerable damage occurs in some seasons, as a result of the growth of fleshy fungi, or "mushrooms" in the seed-bed. These fungi cause damage indirectly, either by raising the surface of the soil, thus causing the soil to dry and the seedlings to wither, or by killing the seedlings as a result of the decay of the mushrooms.

Conditions Favouring This Trouble

Insufficiently decomposed manure or decaying wood and leaves under the beds, along with poor drainage, shading of the beds and inadequate ventilation, are common causes of mushroom growth.

Control Measures

Where sterilization of seed-bed soil is practised trouble from these fungi is not usually experienced. If manure or other organic matter is used, care should be taken that it is thoroughly rotted, and if these fungi appear in seed-beds, remove them carefully and ventilate as well as possible.

Yellow-patch

During the past few years a "yellow-patch" condition has been encountered in seed-beds in Essex, Kent, Elgin, and Norfolk counties in Ontario. This trouble is distinct from damping-off, since affected seedlings, though stunted and yellow, show no surface injury as is the case with damping-off. Though the roots of "yellow-patch" plants are generally brown in colour or have brown lesions, they sometimes appear to be white and normal in every respect. Seed-beds have been observed where this trouble necessitated re-seeding two or three times, while in other cases the seedlings apparently outgrew the condition.

Cause

Recently a "yellow patch" disease with symptoms similar to that found in Ontario, has been reported from Australia, as being caused by too high a concentration of organic nitrogen in the seed-bed. In Ontario yellow patch has generally been associated with, and has been produced artificially by, over-fertilization, especially with sheep manure or other manures. Accordingly, manures are not recommended for use in seed-beds.

Control

All mucks should be chemically analysed for essential elements and fertilization recommendations strictly adhered to.

Blue Mould

Blue mould is a serious disease of tobacco which, since 1921, when a severe outbreak occurred in Florida, has been advancing gradually northwards until in 1938 it reached the Old Belt of the Ontario tobacco-growing district.

Symptoms

This disease causes most damage on seedlings approaching the transplanting stage, but both younger seedlings and plants in the field may become infected. Blue mould may be first detected by the downward cupping of the tips of affected leaves, and the presence of irregularly shaped yellow blotches

on the upper surface of leaves. However, the most characteristic symptom is the presence on the under surface of affected leaves of a dense greyish-blue "down" or mould which has given rise to the common name, blue mould (Fig. 2). Under moist conditions entire leaves soon become involved and appear as though scalded, and give off an offensive odour of decay. On the other hand, if the weather has been dry and warm, affected portions dry out and become brown and shrivelled with little or no "down" appearing on the lower surface. However, with a return of cool, moist conditions, the disease progresses and "down" develops on affected portions. Frequently the disease develops in patches in the seed-bed, which manifest a yellowish appearance and a pronounced tendency to wilt. In cases of severe attack, the plants ultimately collapse and die. Temporary recovery often occurs but may be followed by secondary outbreaks during cool, wet weather.

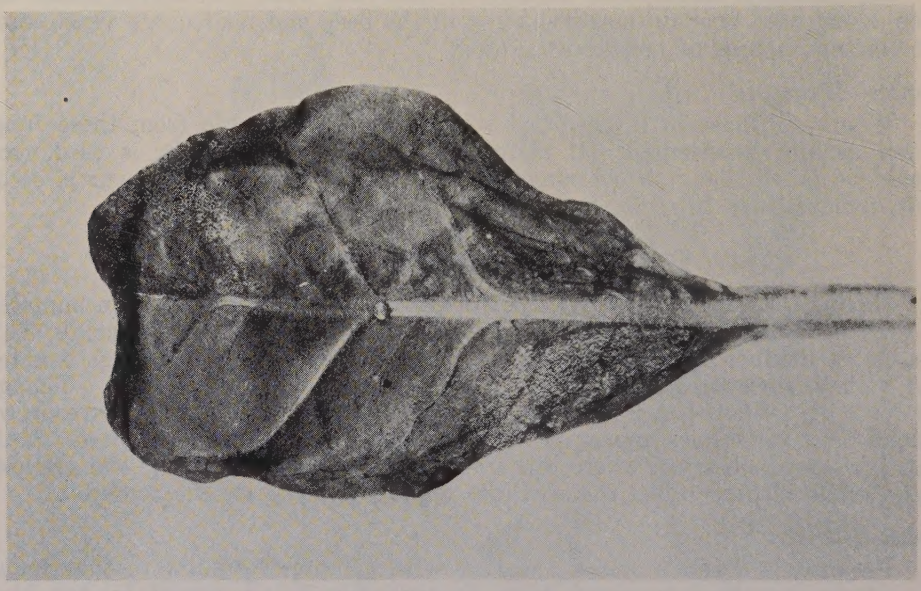

FIG. 2.—Blue mould on tobacco. Note the downy growth at lower right and upper left.

Cause

Blue mould is caused by a fungus called *Peronospora tabacina* Adam.

Conditions Which Favour the Disease

Humid atmospheres and low temperatures, both of which conditions often occur during May and early June in Ontario tobacco-growing districts are favourable for the development of blue mould. In general, it may be stated that the fungus is most active at and below temperatures of 60° F., and becomes inactive at temperatures higher than 85° F.

Control

In other tobacco-growing districts where blue mould has caused damage, three methods of treatment for control have been developed: benzol gas fumigation (the benzol may be placed in shallow pans, distributed throughout tightly-covered seed-beds and left for the night during the period critical for infection); paradichlorbenzol fumigation (crystals allowed to evaporate in covered seed-beds during critical periods); and spraying with a mixture of red copper oxide, emulsified cottonseed oil, and water. In Ontario, these three

methods of control have been investigated and a special circular on "Control of Blue Mould" has been prepared. Ask for this circular at your nearest laboratory of plant pathology or experimental farm, or write the Dominion Laboratory of Plant Pathology, St. Catharines, Ontario.

FIELD DISEASES

Mosaic

Mosaic is a most contagious disease affecting tobacco, and accordingly its distribution is very widespread. Mosaic may be spread by merely touching or brushing against a diseased plant, and then touching a healthy one.

FIG. 3.—Mosaic tobacco plant.
(Courtesy of Tobacco Division, Dominion Department of Agriculture)

Symptoms

Symptoms of mosaic range from a fine, indistinct mottling, with little or no distortion of leaves or stunting, to a very pronounced mottling of alternate dark green and lighter green areas accompanied by severe distortion of leaves and stunting of the plant as a whole (Figs. 3 and 4). The most pronounced symptoms are generally to be found at the top, on the more-recently-formed leaves. Under certain conditions the lower leaves of mosaic plants develop numerous dead spots, the so-called "rust" stage of mosaic.

Preventive Measures and Control

Since there are several important ways in which mosaic may be transferred from one crop to another, the following precautions are recommended: (1) the soil in the seed-bed should be sterilized; (2) the seed-bed should not be located near the curing barn or warehouse; (3) tobacco should not follow tobacco in the rotation, but rather some other crop, such as rye, should intervene; (4) the use of tobacco (smoking, etc.) should not be permitted while working with tobacco plants; (5) before old boards and canvas are used a second time for seed-bed purposes, they should be sterilized; and (6) the hands should be thoroughly washed before working with tobacco.

If the above precautions are strictly followed, and clean seed is planted, a seed-bed of healthy plants should be the reward.

85289—2½

If, for any reason, mosaic appears in the seed-bed, the affected plants and the surrounding healthy plants should be removed and destroyed. Avoid weeding or rogueing in the seed-bed when the plants are wet.

Experience has shown that tobacco plants are very subject to mosaic infection during transplanting. Therefore, the hands of the workmen should be thoroughly and repeatedly washed. Experience has also indicated that it is preferable to transplant under comparatively dry conditions since a higher percentage of mosaic has been found in fields transplanted during rain, or when the soil and plants are unduly wet.

FIG. 4.—Leaf from mosaic plant showing mottling.

When the initial percentage of mosaic in the field is small, it is advisable to rogue all diseased plants. This should be done before each cultivation, in order that mosaic may not be spread during cultivation. Also, tobacco should not be cultivated when the plants are wet, since mosaic is spread more rapidly under such conditions. It is not advisable to re-set healthy tobacco plants in soil from which mosaic plants have been rogued, because a high percentage of such plants become infected with mosaic.

It has already been pointed out that mosaic is spread during cultivation. Therefore, implements used in plantations containing mosaic should not be used in a mosaic-free plantation, unless such implements have been thoroughly washed or disinfected. In suckering and topping, treat all healthy plants first as a group, leaving the mosaic plants till later.

Ring Spot

This virus disease is of little importance in Ontario or Quebec, though it is found each year, particularly in the Old Belt in Ontario.

Symptoms

The outstanding symptom is yellow rings or concentric line patterns on the leaf (Fig. 5), which later break down, giving rise to rings of dead tissue. Affected plants are often stunted in growth. As with mosaic, ring spot has a wide range of weed hosts, and unlike mosaic, it may be carried in the seed from affected plants.

FIG. 5.—Ring spot on tobacco leaf.

Control

1. Use seed from healthy plants. 2. Do not permit weeds in seed-bed or field. 3. Rogue and destroy diseased plants early in the season.

Streak

The first case of this disease was found in Ontario in 1937. It was again observed in 1938, when it caused appreciable loss in a few tobacco fields in Kent county. In 1939 a few cases were found in both Ontario and Quebec.

Symptoms

The most common symptom consists of dead areas of leaf tissue, in the form of fine dots, rings, and streaks, which may involve the greater part of the leaf blade (Fig. 6). Conspicuous brown necrotic (dead) areas may also be present on the stalk and leaf petioles. Not all leaves of an affected plant necessarily show necrosis, in fact generally only 2 or 3 centre leaves show symptoms, the remainder appearing to be normal. The leaves above the necrotic section may or may not show an indistinct mottle, but are invariably narrower than normal. On some varieties, especially Kelley and White Burley, the tip of the plant often becomes twisted or crooked.

FIG. 6.—Tobacco streak. Note the fine necrotic spotting and distortion of leaves. Also note that top of plant is twisted.

Nature of the Disease

Investigations carried out at St. Catharines have demonstrated that this new disease is similar to Johnson's streak. Like tobacco mosaic, with which all growers are familiar, streak is a virus disease, but whereas mosaic is very contagious and is therefore readily spread by contact, streak is much less contagious and little, if any, spread results from contact, cultivation, etc. Though mosaic overwinters in the soil, so far as is known streak does not. The evidence to date indicates that streak overwinters in some perennial weed or weeds, and is carried from such weeds to tobacco by insects. This would indicate that streak is not apt to be a serious disease in Ontario tobacco fields.

Control

Until the weed or alternate crop hosts and the insect vector or vectors connected therewith, are definitely known, little in the way of control can be suggested beyond recommending the destruction of weeds in or near tobacco fields. This is good practice, not only for streak, but for mosaic as well, since certain weeds harbour mosaic.

Tobacco growers should be on the lookout for this new disease and should report all cases to their nearest plant disease laboratory or experimental farm.

Black Root-Rot

In the older tobacco-growing districts of Canada, black root-rot is often a serious disease, especially during cool, wet seasons. This disease may be severe either in the seed-bed or in the field, but losses result chiefly from infection of plants in the field. Up to the present time, black root-rot has been most serious in Essex and Kent counties of Ontario and the tobacco-growing districts of Quebec.

Fig. 7.—Black root-rot in the field.
(Courtesy of Dominion Experimental Station, L'Assomption, Quebec.)

Symptoms

As the name indicates, the disease is characterized by a rotting of the roots which results in a starvation of affected plants. The disease can usually be identified by an examination of the root system, which is reduced in size, and is characteristically black in colour, either wholly or in part, depending on the severity of infection. The root system of infected seedlings is often completely decayed (Fig. 8). Above-ground symptoms consist of wilting and stunting, frequently accompanied by yellowing of the leaves, especially on younger plants, and often by a premature budding-out (Figs. 7 and 9). Both seed-beds and fields which are infested with black root-rot have a decidedly patchy appearance, some plants showing much greater growth than others.

Cause

Black root-rot is caused by the fungus *Thielaviopsis basicola*. This parasite is able to attack certain other plants, including beans, soybeans and red clover, as well as tobacco, and is capable of overwintering and living year after year in the soil, in the absence of tobacco.

Conditions Favouring the Disease

Too much moisture, low soil temperature and alkaline soils favour the development of black root-rot. On the other hand, drought, high soil temperature or acid soil may prevent the disease from becoming serious, and often account for the late recovery of plants affected with black root-rot. Prolonged wet weather following transplanting usually results in more severe damage from black root-rot than abundant moisture later on, probably because of the lower temperatures prevailing at transplanting time. The application of lime to soils infested with black root-rot is almost certain to result in severe damage from the disease even though other factors may not be entirely favourable for its development.

FIG. 8.—Black root-rot on tobacco. Note rotted and blackened roots with a few healthy laterals on upper part of root.

Control Measures

Black root-rot may be prevented in the seed-bed by sterilization of the seed-bed soil with steam, or disinfection with formalin. The practice of avoiding the transplanting to the field of plants with black areas on their roots is doubly important, (*a*) because infected plants will either die or grow very slowly during the early part of the season, and (*b*) because infected seedlings will either inoculate field soil hitherto free from this serious disease or encourage an accumulation of the disease in soil possibly only mildly infested up to that time.

Prevention of black root-rot in the field is obtained chiefly in two ways, (1) by a crop rotation of three years or longer, and (2) by the use of resistant varieties. In Canada it is not safe to plant varieties of tobacco susceptible to black root-rot in infested soil oftener than once in every three years on the lighter soils, and for a longer period on the heavier soils. Concerning the rotation of other crops with tobacco, it must be kept in mind that beans, soybeans and red clover also become infected with black root-rot. On the other hand, small grains, most truck crops, and corn remain free from the disease.

A knowledge of the soil alkalinity or reaction is also highly important when a grower intends to plant tobacco in a particular field. A soil reaction test by the nearest Experimental Station will determine for him whether it may be safe or unsafe from this standpoint to plant a susceptible variety on his land.

Care should be taken to keep fields free from infestation by this fungus and since the disease can be carried on field machinery and equipment, tools should not be transferred for use from contaminated fields to non-contaminated ones without first washing them, preferably with a disinfectant such as formalin.

FIG. 9.—Black root-rot showing relative resistance of Havana 142, a cigar binder variety grown in Quebec. No. 10 Connecticut Havana 38 and No. 11 Resistant Havana 142. (Courtesy of Dominion Experimental Station, L'Assomption, Quebec.)

The use of resistant varieties is highly important in the control of black root-rot. Though the more resistant varieties may not, at present, possess all of the desirable commercial characteristics, nevertheless, in a choice of varieties serious consideration should be given to them by growers. Considerable knowledge is at present available regarding the differences in susceptibility of the varieties more commonly grown in Canada, and lists of the varieties of each type of tobacco are given below, their relative resistance being approximately in the order they appear, the more resistant ones being named first and the most susceptible ones last.

*Flue-cured varieties: Gold Dollar 82C, Yellow Mammoth, Duquesne, Bonanza, White Stem Orinoco, White Mammoth.

*It should be noted that none of the common flue-cured varieties manifest true resistance and that Harrow Velvet is the only highly resistant burley variety. Note: The information on varietal resistance is based on results obtained at the L'Assomption, Farnham, and Harrow Experimental Stations.

Burley varieties: Harrow Velvet, Kentucky No. 16, Halley's Special, Type No. 5, Gay's Yellow, Kelley, Judy's Pride.

Cigar binder type: Resistant Havana, Havana 211, Havana 236, Connecticut Broadleaf (Williams), Comstock Spanish Pomeroy, Connecticut Havana No. 38.

Pipe varieties: Grand Rouge, Belge, Rose Canelle, Parfum d'Italie, Obourg de Vincent, Petite Havana, and Canelle.

Brown Root-Rot

Introduction and Symptoms

During the past few years brown root-rot has been receiving much attention as possibly one of the most important field diseases of tobacco in the Old Tobacco Belt of southwestern Ontario. It also occurs in the New Belt of Ontario and in the Quebec tobacco-growing districts. As the name implies, the

FIG. 10.—Brown root-rot on tobacco. Varietal Resistance. Left, Judy's Pride; centre, Halley's Special, and right, Kelley.

disease is characterized by a reduction and browning of the root system. The symptoms of brown root-rot are similar to those of black root-rot, with the exception that the root infections are brown instead of black. Above-ground symptoms of brown root-rot are in the main similar to those of black root-rot consisting of stunting, yellowing of the leaves, and premature budding-out (Fig. 10). Plants affected with brown or black root-rot show a decided tendency to wilt, particularly during mid-day, due to the reduced root systems.

Cause

The cause of brown root-rot is imperfectly understood. The incidence of the disease has proved to be closely correlated with the preceding crop. In southwestern Ontario brown root-rot has been observed to be particularly severe where tobacco has followed corn or soybeans in the rotation. The disease also frequently occurs where sod land has been planted to tobacco for the first time. Though brown root-rot may persist in the soil year after year, it is not usually severe after two or more consecutive tobacco crops. Other crops such as tomatoes, potatoes, are also sometimes affected with brown root-rot.

Conditions Favouring the Disease

Little is known regarding the factors which favour the development of brown root-rot. However, after a period of hot, dry weather in midsummer affected fields frequently recover to some extent.

Control Measures

It is an unsafe practice from the standpoint of brown root-rot, particularly on the lighter soils of Essex and Kent counties, to precede tobacco in the rotation with either corn or soybeans. Provided black root-rot is not present it is safer to follow tobacco with tobacco on soil where brown root-rot has developed in the past, since brown root-rot is usually not severe on the second crop of tobacco. From certain other standpoints, however, the latter recommendation is not always advisable.

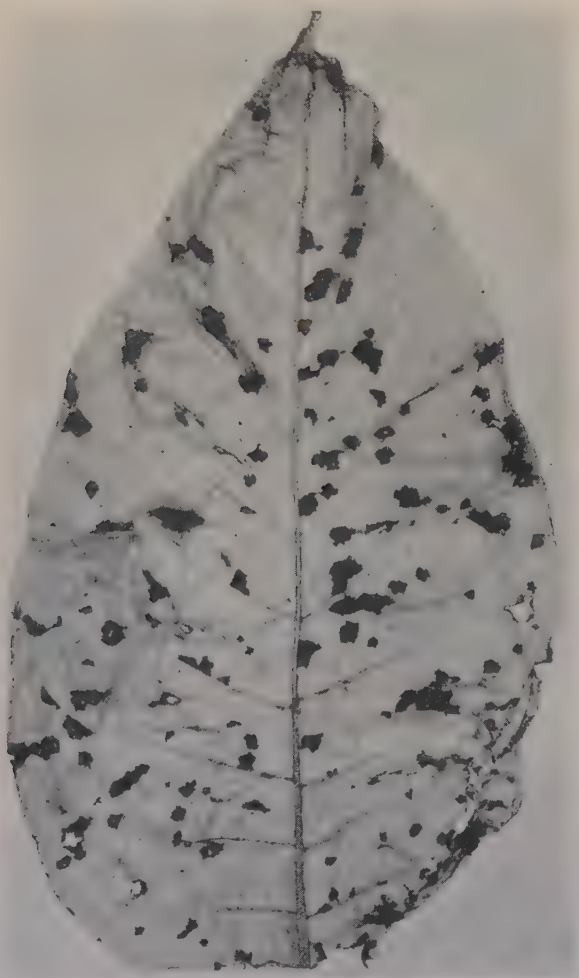

Fig. 11.—Angular leaf spot on tobacco.

Recent experiments have indicated that, of the Ontario-grown burley varieties, Kelley and Judy's Pride are more resistant than Harrow Velvet, Halley's Special, Kentucky White Burley, Gay's Yellow and other varieties.

Of the flue-cured varieties White Mammoth, Bonanza, White Stem Orinoco and Duquesne appear to be more resistant than the varieties Yellow Mammoth, White Stem Willow Leaf, Adcock, Jamaica Wrapper, etc.

Angular Leaf Spot

Angular leaf spot occurs to some extent every year, and during wet seasons it is frequently prevalent and occasionally destructive throughout the tobacco-growing districts of both Ontario and Quebec. Due probably to the higher summer rainfall in Quebec, the disease is usually more severe in the Quebec than in the Ontario tobacco-growing districts.

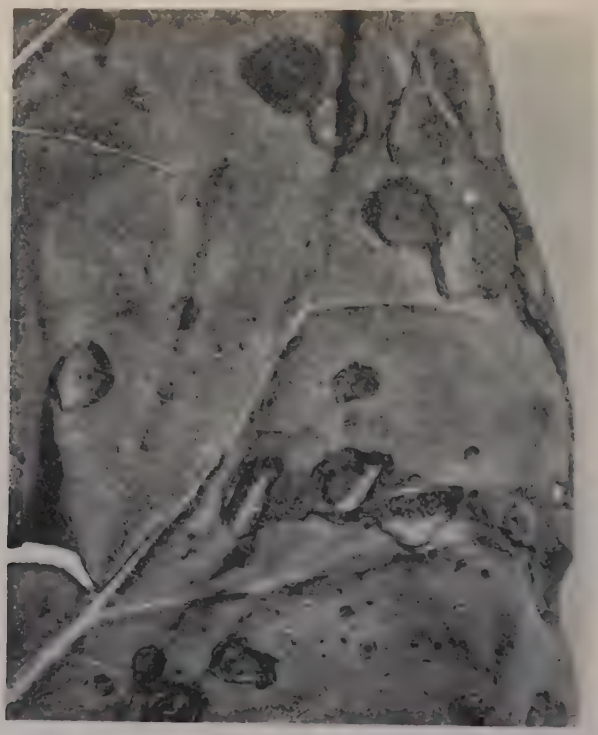

FIG. 12.—Angular leaf spot showing large zonate type of spots.

Symptoms

This disease may appear on plants at any stage of development from seedling to maturity. On seedlings first signs of the disease usually are several angular, dark-coloured spots on a single leaf. These spots are generally much smaller than those on mature plants and have a narrow, translucent margin. On plants in the field the spots are characteristically angular and vary in size (Fig. 11). Spots on dark tobacco are usually large and zonate (Fig. 12). Recent investigations in the United States on angular leaf spot and on wildfire, which resembles angular leaf spot closely and is described later, indicate that following severe rainstorms the ordinarily small leaf spot caused by the bacteria may involve large areas and sometimes entire leaves, due to the water-soaking of tissues around the spots, and their subsequent invasion by the bacteria. In such cases often little leaf tissue remains attached to the stalk.

Cause

Angular leaf spot is caused by a bacterium named *Phytomonas angulata*. This parasite is capable of invading tobacco leaves, especially through injuries. Under conditions of excessive moisture within and on the leaf, the bacteria multiply rapidly and then serve as sources of further infection on the same or other leaves. Some of the bacteria overwinter successfully, probably on tobacco trash, seed, seed-bed cloth, and by other means, and these serve to renew the disease each spring, unless treated as shown below under control measures.

Conditions Favouring the Disease

Wind and rainfall play major rôles in the dissemination of the bacteria causing angular leaf spot, both in the field and in unprotected seed-beds. This is due to the fact that the splashing of the rain, as a result of wind, spreads bacteria from leaf to leaf and from plant to plant, and also watersoaks large portions of the tissue, thus enabling easy access to and invasion of hitherto healthy tissues by the bacteria. High temperatures also favour the disease.

Control Measures

Control measures for this disease largely centre around the problem of obtaining healthy seedlings. Seed pods showing no sign of infection should always be selected for seed. The selection of seed should be supplemented by disinfection with silver nitrate according to instructions already given (page 5). Where angular leaf spot has been severe, the seed-beds should either be steamed, or if possible be established on new ground, well removed from fields in which tobacco has recently been grown. Old tobacco refuse should not be used on seed-beds. When cloth is used, it should either be renewed each year or sterilized in boiling water. It should also be kept in mind that this disease may be spread by the hand or clothing of workers during the various operations; also that the disease spreads more readily from infected plants that are wet than from those that are relatively dry. The rotation of other crops with tobacco and the early ploughing-under of stubble are also good preventative measures.

Wildfire

Wildfire is a leaf spot disease which resembles angular leaf spot very closely in most respects. In Canada this disease has been sporadic in its appearance. It has appeared most frequently in the Yamaska valley in Quebec, and has been observed occasionally in the tobacco district north of Montreal and at Ottawa. It may also occur occasionally in the Ontario tobacco-growing districts, and a careful watch should be kept at all times for its occurrence.

Symptoms

Though wildfire is primarily a leaf spot disease it also occurs upon the flowers and seed pods. It may appear on the leaves at any time from the seedling to the mature plant stage. A wet-rot phase often appears earliest and involves the leaf margins and tips of affected plants with a watersoaked zone between the living and the dead tissue. This phase is followed at about transplanting time by one in which tiny, circular, yellowish-green spots appear on other leaves. In a short time a small, brown area appears in the centre of each spot, and the wide, yellowish-green margin or halo becomes more prominent (Fig. 13). The spots increase in size and prominence, often reaching a diameter of ½ inch or more. In addition to this type of lesion which develops under ordinary conditions, a much larger and more destructive type of spot develops after severe storms. In such cases large areas of leaves and sometimes whole leaves become infected and die, with little or no halo effect at the margins.

Cause

Wildfire is caused by the bacterium called *Phytomonas tabacum.* This parasite resembles very closely the one causing angular leaf spot in both appearance and behaviour. It over-winters apparently by the same means as angular leaf spot.

Conditions Favouring the Disease

The conditions that favour angular leaf spot also favour wildfire.

Control Measures

The control measures outlined for angular leaf spot apply equally well to wildfire.

FIG. 13.—Wildfire on tobacco. Note halo surrounding dead central area.

Non-Parasitic Leaf Spot

This small brown leaf spot which later may or may not turn white, has been encountered repeatedly during the past few years on flue-cured and burley varieties, though observations to date would suggest that it was more general and most severe on flue-cured varieties (Fig. 14). In 1936 this leaf spot was general in the Delhi district and on plots at St. Catharines, and to a lesser

extent in the tobacco-growing districts at Harrow in Ontario, and at L'Assomption and Farnham, Quebec. In 1937 and 1938 it was particularly severe in a flue-cured field at L'Assomption and in numerous fields in the New Belt in Ontario. At St. Catharines, this leaf spot was severe on a section of the laboratory farm known to be low in fertility, while it was almost entirely lacking on similar varieties on a well-fertilized section.

Fig. 14.—Two types of non-parasitic leaf spots.

Symptoms

The disease first manifests itself as small brown spots, which later become dead and often turn white. With burley varieties especially, an indistinct halo sometimes surrounds the dead tissue. The degree of spotting may vary from a few widely-separated ones to a condition in which the leaf is entirely covered with spots. Badly affected leaves do not mature normally and as a result are lowered in grade.

Cause

The cause of this disease is as yet unknown. It may be the result of an improper potassium-nitrogen balance in which high phosphate content of the soil has a tendency to alleviate the trouble.

Control

At the present time no control measures can be recommended beyond suggesting that analysis of the soil be made and fertilizer recommendations be followed.

Frenching

Frenching may be found in the seed-bed (Fig. 15) or in the field (Fig. 16). Several cases of frenching have been observed in seed-beds in both Quebec and Ontario. Under seed-bed conditions frenching is sometimes confused with mosaic, although it is a distinct disease and of rather infrequent occurrence. In 1938 frenching was widespread in the New Belt in Ontario.

Fig. 15. Frenched tobacco seedlings.

Symptoms

The earliest symptom is a chlorosis of the margins of young leaves which later spreads toward the mid-rib until ultimately the whole leaf becomes yellow, with the network of veins green. Severely-affected plants are stunted and the leaves often become elongated, narrow, and severely distorted. The tips of the leaves often curl downward, while the margins become wavy or undulated. Under certain conditions affected plants produce an unusually large number of small, strap-like leaves. Sometimes it is found on suckers only, the rest of the plant appearing to be normal. Both in Ontario and Quebec some of the most severe cases of frenching have been observed on light soils that have grown tobacco for the first time.

Cause

The cause of frenching is not clearly understood, though recent work would indicate that it may be due to toxic substances, one of which is thallium. There is some reason to believe that lack of aeration, excessive moisture in poorly-drained soils, and the reaction of the soil are contributing factors. Experimental evidence and field observations indicate that frenching is greatly favoured by an alkaline soil.

Control

Frenching does not appear to be so prevalent on well-drained and fertilized soils that have an acid reaction. Also, tobacco should not be grown on soil that has repeatedly grown crops of severely frenched tobacco.

FIG. 16.—Severe frenching in the field. 1. Severe frenching; note strap-like leaves. 2. Row of severely frenched plants between two rows of mildly frenched plants.
(Photo by P. G. Newell)

Hollow-Stalk

Though this disease is as yet of no great importance, it has been found both in Ontario and Quebec. It is favoured by wet seasons.

Symptoms

Black, diseased areas on the stalk in the form either of stripes or of complete girdling, and hollow stalks caused by the destruction of the pith are diagnostic of this disease. The bacteria which cause hollow-stalk enter through wounds, and it has been observed both in Ontario and Quebec that infection apparently took place through wounds resulting from topping.

Cause

This is a bacterial disease, probably caused by *Erwinia carotovora* Jones or *Erwinia aroideae* Towns.

Control

This disease is as yet of such minor importance that preventive measures are unnecessary.

Root-Knot

Under conditions of high soil temperature, root-knot may be a serious disease of tobacco in light soils. Though the disease has been comparatively unimportant in Canada to date, it has been found in Ontario attacking both tobacco seedlings and plants in the field.

Symptoms

This disease is characterized by knot-like enlargements varying in size from scarcely visible swellings on the smaller rootlets, to elongated swellings an

inch or more in diameter on the larger roots. Affected seedlings become stunted and yellow and usually occur in patches in the seed-bed. In the field infected plants are stunted and wilt readily in dry, hot weather, and may eventually be killed.

Cause

Root-knot is caused by the nematode or eel-worm called *Heterodera marioni.*

Factors Favouring the Disease

Light, sandy soils favour the development of the disease much more than do the heavier soils. Plants grown in fields where the nutrient level is low are more severely affected than where an abundance of mineral nutrients is present. High soil temperatures are especially favourable for nematodes, and they become inactive as soon as temperatures drop to 50° F. or lower.

Control Measures

In the control of root-knot it is essential, in the first place, to prevent infection of seedlings in the seed-bed. Sterilization of the soil by steam or chemical will destroy the nematodes if present, and they are not apt to be present in the seed-beds if the latter are located on land which has not recently been cultivated. When fields become infested it is possible to control root-knot only by practising a system of rotation in which non-susceptible crops are grown for a period of years. Usually three years are sufficient to keep down weeds on which the nematodes feed. Such crops as corn, wheat and rye can be grown safely during this period. The application of nitrate of soda has also been shown to somewhat counteract loss due to these nematodes.

Albinism

Occasionally on the foliage of certain tobacco plants in the field can be observed large or small, irregularly shaped patches, almost pure white to yellowish in colour, which give a marbled appearance to affected plants. These patches are usually limited by the veins and the colour of the upper and lower surfaces of affected areas in the leaf may be either the same or different.

This condition on tobacco plants resembles variegation in horticultural plants such as geranium, for instance, where this abnormality is valued. It does not appear to be infectious and appears to be hereditary to some extent.

Lightning Injury

Lightning injury is occasionally observed, and when present is found in more or less circular areas, with the plants in the centre most severely affected, and often killed, whereas the plants towards the margin of the area are less severely affected and show various symptoms. In the latter instance, the leaves on one side may be wilted or dead, while those on the other may be normal. A brown to black streak or band may extend along one side of the stalk and out into the petioles and mid-ribs of the leaves, causing a puckering of affected leaves with wilting. Later the growth of normal tissue of affected plants often causes the stem to turn downward or twist, and the leaf tissue becomes puckered (Fig. 17).

Hail Injury

In 1937 hail caused considerable damage both in Ontario and Quebec, though its distribution was quite limited in area. If hail strikes small plants, they may outgrow the damage to a considerable extent. Plants with larger leaves obviously are more seriously damaged and the crop may be a total loss, with the leaf blade shredded and even the plants uprooted. Grey, sunken areas mark the places where the hail stones strike the stalks and petioles (Fig. 18).

FIG. 17.—Lightning injury.

FIG. 18.—Hail injury.

SYMPTOMS ON TOBACCO ASSOCIATED WITH A DEFICIENT SUPPLY OF CERTAIN CHEMICAL ELEMENTS

Potash Deficiency

Where potash is deficient, characteristic symptoms develop. The lower leaves of affected plants manifest a mottling or chlorosis towards their tips and margins, which is soon followed by a breakdown in the form of dead spots in the leaf tissue. This dead tissue may involve the tip only, or the entire leaf. The margins and tips of affected leaves often curl downwards and

FIG. 19.—Effects of potash deficiency on tobacco.
(Photo by P. G. Newell)

inwards (Fig. 19). As the condition progresses, affected leaves take on a ragged, rusty appearance, often with a noticeable puckering of the tissues between the veins. The mottling or chlorosis of the leaves usually progresses upwards on the plant, but the bud leaves always retain their normal colour. Dry weather tends to exaggerate these symptoms. Cured leaves from a crop suffering from potash starvation are thin and dull in appearance, and lack elasticity, aroma, and satisfactory burning quality.

Nitrogen Deficiency

Nitrogen is essential to the tobacco plant, both for growth and quality of the cured leaf. For burley and especially flue-cured tobacco, the nitrogen supply should be available in decreasing amount as the crop matures so as to secure proper growth and ripening. A deficiency of nitrogen is manifested by the tobacco plant at any stage from seedling to mature plant. The earliest symptom is a slight yellowing of the foliage, accompanied by a slowing down of the growth rate. Later, the bottom leaves change to an orange yellow colour and still later dry up. At this time the uppermost leaves often assume an abnormally erect position. The bud leaves tend to retain their normal colour. Though flue-cured tobacco is normally ripened under deficiency of nitrogen conditions, too great a shortage of this element too early in the growth of the plant may result in a reduction of leaf size and lack of the desired "body" of leaf.

Phosphorus Deficiency

When phosphorus is not supplied to tobacco plants in sufficient quantity, they assume an abnormally dark green colour and a rosette condition. Growth is delayed and leaves are narrower than normal leaves. Small, dark brown, dead areas have also been observed in some seasons on plants supplied with insufficient phosphorus. Leaves from phosphorus deficient plants remain immature and hence give an unsatisfactory colour when cured, tending to be brown or black.

Magnesium Deficiency (Sand Drown)

This disease has been recognized in the United States since 1912, and was known as sand drown many years before its relation to deficiency of magnesium in the soil was determined. While not prevalent in Canada, it may occur on the more sandy soils, particularly in seasons of excessive rainfall.

Symptoms of magnesium deficiency are striking and destructive. Affected plants, which are usually not evident until late in the growing season, become characteristically chlorotic. This yellowing begins at the tips and margins of the bottom leaves and continues until in severe cases entire leaves and most of the plant manifest symptoms. It is characteristic for the veins and a certain amount of adjacent tissue of affected leaves to retain their normal colour. Affected leaves assume a dull, pale yellow colour, and after curing, lack good colour, are thin, lifeless, and break easily at the tips. If indications of potash, nitrogen, phosphorus or magnesium deficiencies are noted, soil samples should be taken to the nearest Experimental Station for chemical analysis and advice as to corrective measures.

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